

Variation in Low-Value Radiograph Utilization for Children in the Emergency Department

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Background

‘Low-value care’ describes medical interventions without additional benefit when compared to a less costly alternative.^{1,2} Decreasing ‘low-value care’ has been identified as a priority to reduce wait times, patient exposure to harm and anxiety, and unnecessary costs.^{1,2} Diagnostic imaging (DI) is a major contributor to low-value care in the emergency department (ED).³⁻⁵ Low-value DI is an important issue for pediatric patients, who are at increased risk of harm because of their increased susceptibility to ionizing radiation,⁶ and the harms related to unnecessary treatments associated with radiograph use.^{7,8} Overuse of imaging in the ED accounts for 3 of the first 5 American Academy of Pediatrics Choosing Wisely recommendations, and 6 of 10 Choosing Wisely recommendations among emergency physicians in Canada.^{9, 10}

Practice variation that cannot be explained by patient illness or preferences is labelled as unwarranted, and leads to variations in low-value care.¹¹ Unwarranted practice variation exists in the emergency care of children,^{11, 12} and differences in ED settings are important contributors to this phenomenon.^{4, 11-16} Specifically, EDs with pediatric designation provide higher-value care and are associated with improved outcomes for respiratory emergencies in children.^{3, 17-21} Institutions with higher pediatric patient volumes are associated with better adherence to immunization guidelines in primary care and to resuscitation guidelines in the ED setting.²²⁻²⁴ Practice variation in the emergency care of children is also attributed to physician characteristics, with pediatric emergency specialty training leading to higher-value care when compared to other physician specialties.^{17, 24-26} While some of the aforementioned studies focused on radiograph use in the ED,^{3, 18, 19, 21, 26, 27} few studies have looked across multiple diagnoses and/or ED settings to identify predictors of practice variation.^{17, 25, 28} Identifying setting and provider-specific characteristics contributing to low-value radiograph use will inform the development of quality improvement (QI) interventions, known to be effective in improving pediatric care,²⁹⁻³³ to decrease unnecessary radiographs.

To address this, we aimed to evaluate variations in radiograph use for four common pediatric ED diagnoses for which radiographs are not generally recommended: bronchiolitis, asthma, abdominal pain and constipation. Together, these diagnoses represent 15-20% of all pediatric ED visits.³⁴⁻³⁷ Our objective was to compare x-ray utilization between (a) ED settings (hospital-type and pediatric volume), and (b) ED physician specialties.

Methods

Study design

This was a population-based study of all pediatric (0-18 years) unscheduled ED visits to any hospital in the province of Ontario, Canada, during the 2010 to 2019 calendar years.

Population and data sources

Data were obtained from linked population-based administrative health databases housed at ICES, formerly the Institute for Clinical Evaluative Sciences, an independent research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care demographic data, without patient consent, for health systems evaluation and improvement. ICES uses unique encoded identifiers to link an individual's records across databases over time while preserving anonymity. Databases used included the National Ambulatory Care Reporting System (NACRS), the Ontario Health Insurance Plan database (OHIP), the Canadian Institute for Health Information's Discharge Abstract Database (CIHI-DAD), the Ontario Registered Persons Database (RPDB), the Citizenship and Immigration Canada Permanent Resident Database (CIC), the ICES Physician Database (IPDB), the Ontario Institutions Database (INST), the Ontario Asthma Dataset (ASTHMA), and the Postal Code Conversion File (PCCF).

We selected all visits by children discharged from the ED with diagnoses for which radiographs are not routinely recommended [asthma (chest x-ray),^{18, 38} bronchiolitis (chest x-ray),³⁹ abdominal pain (abdominal x-ray),⁴⁰ constipation (abdominal x-ray)].⁴¹⁻⁴³ We excluded patients who were admitted to hospital, transferred from or to another facility or died in the ED, to focus on a low-risk population of patients. A privacy impact assessment and approval was obtained from ICES' Privacy & Legal Office, and the study was deemed exempt from Research Ethics Board approval at SickKids, as analysis was conducted using administrative data for the purposes of health system evaluation.

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Variables

For each index ED visit, we collected patient demographics (age, sex, income quintile, immigration status, presence of a chronic complex condition⁴⁴) and characteristics of the ED visit, including Canadian Triage Acuity Score [CTAS], (a validated triage score used to predict illness severity for pediatric patients),⁴⁵⁻⁴⁸ time, and day of presentation. We collected characteristics of the physician (sex, domestic vs foreign training, years in practice, specialty), and hospital characteristics (academic status, pediatric patient volumes).

Exposures

Hospital-type was defined using the hospital designation reported in the INST database, and separated as: a) Pediatric academic hospitals (n=4), b) Adult academic hospitals (n=18), and c) Community hospitals with and without consultant pediatricians (n= 52 and 107, respectively). Pediatric consultation availability was defined based on the frequency distribution of pediatric consultations at each hospital; those with fewer than two consultations per week in the ED were presumed not to have regular access to pediatric consultation services. We also defined ED setting by pediatric volumes, using the average annual hospital pediatric ED visit volumes over the study period, and dividing the volumes into tertiles (low, medium, high).

The ED physician was identified through ED billing codes for services rendered during, or within 24 hours of, the index ED visit. Specialty training was identified for each physician as documented in the IPDB database. If more than one ED physician was associated with the index ED visit, the physician specialty most likely to be providing care within an ED setting was chosen, according to the following hierarchy: pediatric emergency medicine (PEM), emergency medicine (EM), family medicine with additional EM training, pediatrics, family medicine and other specialties.

Outcomes

Radiograph utilization was identified through emergency radiology billing codes used during, or within 24 hours of, the index ED visit. We assessed whether patients discharged without imaging had deleterious outcomes by examining the rates of ED return visits, hospital admission, intensive care unit (ICU) admission, or mortality within 7 days after the index visit.

Analyses

We used logistic regression to evaluate the odds of radiographs for each condition by hospital characteristics (hospital-type and pediatric volumes) and by physician specialty. In our models, we adjusted for patient demographics (age, sex, household income quintile, immigration status, and presence of complex chronic conditions), ED visit characteristics (CTAS score, time/day of ED presentation), and physician characteristics (sex, domestic/foreign training, and years in practice).

Since children are more likely to receive imaging when they have underlying health issues or with repeated ED visits, which may be indicative of diagnostic uncertainty, sensitivity analyses were conducted: a) excluding patients with complex chronic conditions, and b) excluding any return visits within 72 hours of an index ED visit. We also performed a sensitivity analysis excluding lowest-volume hospitals, which may have limited resources, to ensure that imaging availability did not affect our results.

Comparisons in the rates of balancing measures between patients with and without imaging for each diagnosis were evaluated using standardized risk differences. Yearly radiograph utilization rates were calculated for each diagnosis to assess for trends. Analyses were completed using SAS version 9.4 (SAS Institute, Inc), and p-values less than 0.05 were considered statistically significant.

Results

During the study period, there were 9,862,787 eligible pediatric ED discharges in Ontario. Of these, 60,914 children were discharged with bronchiolitis, 141,921 with asthma, 333,332 with abdominal pain, and 110,514 with constipation. (Figure 1) The mean age (SD) was 8 years (6.1) and 335,019 (51.8 %) of participants were female. In this cohort, 12,883 (2.0%) patients had a complex chronic condition, 25,501 (3.9%) had immigrant/refugee status, and 101,573 (15.7%) lived in a rural setting. (Table 1)

The overall rate of radiograph use in our cohort was high at 26.0%, and ranged from 18% for children discharged with abdominal pain, 27% for asthma, 37% for bronchiolitis, to 41% for constipation.

Radiograph use by hospital-type

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3 Patients discharged with bronchiolitis and asthma were more likely to have a chest radiograph
4 when seen in non-pediatric EDs, compared to pediatric EDs (the referent), with highest use in
5 adult academic EDs [adjusted odds ratio, aOR (95% CI), 5.1 (4.6-5.6) for bronchiolitis and 3.0
6 (2.8-3.2) for asthma]. Similarly, children discharged with abdominal pain and constipation were
7 more likely to have an abdominal radiograph when seen in non-pediatric EDs, with highest use at
8 community EDs with pediatric support [aOR (95% CI), 1.6 (1.6-1.7) for abdominal pain and 2.3
9 (2.3-2.4) for constipation]. (Figure 2)

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16 *Radiograph use by pediatric volumes*

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18 Radiograph use was least prevalent among EDs with low pediatric volumes across all discharge
19 diagnoses. Among patients discharged with bronchiolitis and asthma, compared with EDs in the
20 highest volume tertile (the referent), radiograph use was lowest in EDs with low pediatric
21 volumes [aOR (95% CI), 0.66 (0.59-0.73) for bronchiolitis and 0.57 (0.53-0.60) for asthma]. For
22 patients discharged with abdominal pain and constipation, radiograph use was also lowest among
23 EDs with low pediatric volumes [aOR (95% CI), 0.49 (0.47-0.52) for abdominal pain and 0.39
24 (0.37-0.42) for constipation]. (Figure 3)

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31 *Radiograph use by physician specialty*

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33 Children discharged with bronchiolitis were more likely to have a chest radiograph when seen by
34 non-PEM physicians, compared to PEM physicians (the referent), with highest use by family
35 physicians with EM training [aOR (95% CI), 4.8 (4.5-5.2)]. Patients discharged with asthma
36 were more likely to have a chest radiograph when seen by non-PEM physicians, with highest use
37 among EM specialists [aOR (95% CI), 2.8 (2.6-3.0)]. Similarly, patients with abdominal pain
38 and constipation were more likely to have abdominal radiographs when seen by non-pediatric
39 physicians, with highest use among family physicians with EM training [aOR (95% CI), 1.6 (1.6-
40 1.7) and 2.1 (2.0-2.2), respectively]. (Figure 4)

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47 *Balancing measures*

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49 There were no differences in return visits, hospital admission, ICU admission or death between
50 patients who received imaging or not. (Table 2)

Sensitivity analyses

Differences in radiograph use persisted when excluding patients with chronic complex conditions, return ED visits, and lowest pediatric volume hospitals. (Supplemental tables 1-3)

Trends in radiograph use over time

Overall radiograph use was high and stable during our study period (27.8% to 24.8%). Radiograph use decreased for bronchiolitis (43.3% to 35.0%), abdominal pain (19.9% to 16.9%), and constipation (44.4% to 39.5%), and increased for asthma (26.8% to 29.1%).

Discussion

We found that radiograph use was high among children discharged from Ontario EDs with four common pediatric conditions. We also found important differences in radiograph use across ED settings and physician specialties. Radiographs were consistently less likely to be used in pediatric academic centres and by PEM-trained physicians. Hospital pediatric volume did not explain this finding. This study adds to a growing body of literature describing low-value care and its contributors by demonstrating variations in low-value radiograph use consistent across multiple pediatric conditions, and along the spectrum of ED settings and physician specialties managing pediatric ED patients.

Our findings are consistent with reports of higher radiograph use among children diagnosed with bronchiolitis, asthma and croup presenting at non-pediatric EDs.^{17, 18, 20} Many differences exist between general EDs and pediatric EDs which may explain this finding. Continuing medical education and QI initiatives in EDs predominantly serving adult populations are likely focused on adult issues. These may result in knowledge gaps with regards to best pediatric practices, partly explaining the increased use of radiographs at these institutions.^{29, 30, 32, 49}

It is surprising that radiograph use was highest in hospitals with higher pediatric volumes. This finding differs from the large body of 'volume-outcome' literature suggesting that higher volumes lead to better adherence to guidelines and better outcomes, for both pediatric and adult patients.^{22, 23, 50-53} The discordance was possibly driven by the fact that most children in our sample presented to community hospitals. As a result, our high-volume tertile was composed mainly of community hospitals, predominantly oriented towards adult care, with only a minority of patients in that tertile seen in Ontario's four pediatric academic hospitals. Another possible

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explanation is that high volumes in our cohort may have been a surrogate for overcrowding, which leads to increased resource utilization and decreased effective care.⁵⁴⁻⁵⁷ These explanations limit our ability to interpret the impact of pediatric volume on radiograph use, but suggest that hospital-type, rather than pediatric volume, drove the differences in our study.

Improved quality of care has been reported for children treated by pediatric specialists for primary, neonatal, surgical and oncological care.^{50, 52, 58} In the ED setting, findings have been more mixed; PEM physicians were more likely to order low-value tests for patients presenting with lower acuity in one study,²⁶ but less likely to do so for febrile infants in other studies.^{17, 25} We found fewer radiographs ordered by PEM physicians, suggesting that differences in training may affect radiograph use. This variation could be due to cognitive biases caused by higher acuity presentations, higher incidence of chronic disease, and higher admission rates in adult EM.^{59, 60} These suggest that adult ED patients are sicker and more likely to have clinically-relevant findings on radiograph, which may create a bias among adult EM providers to order more radiographs for children as well. While general pediatricians consistently ordered fewer radiographs than adult specialists and generalists, they still ordered more chest radiograph than PEM physicians, suggesting that pediatric exposure in training does not explain all the practice variation reported. The addition of specific skills or exposure to ED-specific clinical practice guidelines in PEM training may also explain some of the variation.^{29, 30, 32}

Our study has limitations. First, our database did not include data on resource availability at different hospitals. Resource availability is an important driver of practice variation,^{11, 12} and is more likely to impact advanced imaging (e.g., ultrasound, computed tomography, or magnetic resonance imaging) than radiographs in the ED setting. This may have affected decision-making in our study: providers working in centres without access to abdominal ultrasound, for example, may be more likely to order abdominal radiographs. However, our findings were robust to sensitivity analyses excluding low-volume hospitals, where such resource constraints are more likely. Second, our exposure definition for physician specialty may have measurement bias. Multiple physicians of different specialties could have been involved in the care of a child in a single visit. In our database, it was not possible to differentiate which physician was the initial provider for a given encounter. Given that most investigations are ordered on initial contact, radiograph use may have been attributed to a physician who was not involved in the decision-

making process. However, our hierarchical approach attributing radiographs preferentially to PEM-trained physicians would have biased our results towards the null hypothesis.

No studies have specifically evaluated the underlying causes of these differences in low-value radiograph use. Our findings suggest that ED setting and physician specialty training warrant further exploration, perhaps through qualitative studies, to inform future interventions.

Conclusion

Our study suggests that radiograph use is high in children visiting the ED. Significant practice variation exists and is driven predominantly by hospital-type and physician specialties. QI initiatives aimed at reducing unnecessary radiographs in children should focus on EM physicians practicing in EDs primarily treating adult patients.

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Confidential

References

1. Bouck Z, Pendrith C, Chen XK, et al. Measuring the frequency and variation of unnecessary care across Canada. *BMC Health Serv Res*. Jul 2019;19(1):446. doi:10.1186/s12913-019-4277-9
2. Canadian Institute for Health Information (CIHI). Unnecessary Care in Canada : Technical report. Ottawa, Ontario, Canada: Canadian Institute for Health Information 2017.
3. Ohana O, Soffer S, Zimlichman E, Klang E. Overuse of CT and MRI in paediatric emergency departments. *Br J Radiol*. May 2018;91(1085):20170434. doi:10.1259/bjr.20170434
4. Tung M, Sharma R, Hinson JS, Nothelle S, Pannikottu J, Segal JB. Factors associated with imaging overuse in the emergency department: A systematic review. *Am J Emerg Med*. Feb 2018;36(2):301-309. doi:10.1016/j.ajem.2017.10.049
5. Sahota IS, Lang E. Reducing low-value interventions in the emergency department: you may be part of the problem. *CJEM*. 03 2017;19(2):143-146. doi:10.1017/cem.2016.349
6. Brody AS, Frush DP, Huda W, Brent RL, Radiology AAoPSo. Radiation risk to children from computed tomography. *Pediatrics*. Sep 2007;120(3):677-82. doi:10.1542/peds.2007-1910
7. Freedman SB, Thull-Freedman J, Manson D, et al. Pediatric abdominal radiograph use, constipation, and significant misdiagnoses. *J Pediatr*. Jan 2014;164(1):83-88.e2. doi:10.1016/j.jpeds.2013.08.074
8. Zipursky A, Kuppermann N, Finkelstein Y, et al. International Practice Patterns of Antibiotic Therapy and Laboratory Testing in Bronchiolitis. *Pediatrics*. 08 2020;146(2)doi:10.1542/peds.2019-3684
9. Choosing Wisely. Ten things physicians and patient should question. In: American Academy of Pediatrics, editor. Philadelphia, PA, 2018.
10. Choosing Wisely Canada. Emergency Medicine: Ten things physicians and patients should question. In: Canadian Association for Emergency Physicians, editor. Toronto, ON, 2017.

11. Wennberg JE. Unwarranted variations in healthcare delivery: implications for academic medical centres. *BMJ*. Oct 2002;325(7370):961-4. doi:10.1136/bmj.325.7370.961

12. Cheung CR, Gray JA. Unwarranted variation in health care for children and young people. *Arch Dis Child*. Jan 2013;98(1):60-5. doi:10.1136/archdischild-2012-302041

13. Hiscock H, Perera P, MacLean K, Roberts G. *Variation in paediatric clinical practice: an evidence check review brokered by the Sax Institute (www.saxinstitute.org.au) for NSW Kids and Families*. 2014.

14. Goodman DC. Unwarranted variation in pediatric medical care. *Pediatr Clin North Am*. Aug 2009;56(4):745-55. doi:10.1016/j.pcl.2009.05.007

15. Chua KP, Schwartz AL, Volerman A, Conti RM, Huang ES. Differences in the Receipt of Low-Value Services Between Publicly and Privately Insured Children. *Pediatrics*. 02 2020;145(2)doi:10.1542/peds.2019-2325

16. Chua KP, Schwartz AL, Volerman A, Conti RM, Huang ES. Use of Low-Value Pediatric Services Among the Commercially Insured. *Pediatrics*. 12 2016;138(6)doi:10.1542/peds.2016-1809

17. Stanley RM, Teach SJ, Mann NC, et al. Variation in ancillary testing among pediatric asthma patients seen in emergency departments. *Acad Emerg Med*. Jun 2007;14(6):532-8. doi:10.1197/j.aem.2007.01.016

18. Knapp JF, Simon SD, Sharma V. Variation and trends in ED use of radiographs for asthma, bronchiolitis, and croup in children. *Pediatrics*. Aug 2013;132(2):245-52. doi:10.1542/peds.2012-2830

19. Hoshiko S, Smith D, Fan C, Jones CR, McNeel SV, Cohen RA. Trends in CT scan rates in children and pregnant women: teaching, private, public and nonprofit facilities. *Pediatr Radiol*. May 2014;44(5):522-8. doi:10.1007/s00247-014-2881-8

20. Michelson KA, Lyons TW, Hudgins JD, et al. Use of a National Database to Assess Pediatric Emergency Care Across United States Emergency Departments. *Acad Emerg Med*. 12 2018;25(12):1355-1364. doi:10.1111/acem.13489
21. Li J, Monuteaux MC, Bachur RG. Variation in Pediatric Care Between Academic and Nonacademic US Emergency Departments, 1995-2010. *Pediatr Emerg Care*. Dec 2018;34(12):866-871. doi:10.1097/PEC.0000000000001036
22. Guttmann A, Manuel D, Dick PT, To T, Lam K, Stukel TA. Volume matters: physician practice characteristics and immunization coverage among young children insured through a universal health plan. *Pediatrics*. Mar 2006;117(3):595-602. doi:10.1542/peds.2004-2784
23. Auerbach M, Whitfill T, Gawel M, et al. Differences in the Quality of Pediatric Resuscitative Care Across a Spectrum of Emergency Departments. *JAMA Pediatr*. Oct 2016;170(10):987-994. doi:10.1001/jamapediatrics.2016.1550
24. Uspal NG, Marin JR, Alpern ER, Zorc JJ. Factors associated with the use of procedural sedation during incision and drainage procedures at a children's hospital. *Am J Emerg Med*. Feb 2013;31(2):302-8. doi:10.1016/j.ajem.2012.07.028
25. Isaacman DJ, Kaminer K, Veligeti H, Jones M, Davis P, Mason JD. Comparative practice patterns of emergency medicine physicians and pediatric emergency medicine physicians managing fever in young children. *Pediatrics*. Aug 2001;108(2):354-8. doi:10.1542/peds.108.2.354
26. Doctor K, Breslin K, Chamberlain JM, Berkowitz D. Practice Pattern Variation in Test Ordering for Low-Acuity Pediatric Emergency Department Patients. *Pediatr Emerg Care*. Mar 2021;37(3):e116-e123. doi:10.1097/PEC.0000000000001637
27. Plint AC, Taljaard M, McGahern C, et al. Management of Bronchiolitis in Community Hospitals in Ontario: a Multicentre Cohort Study. *CJEM*. Nov 2016;18(6):443-452. doi:10.1017/cem.2016.7

28. Cohen E, Rodean J, Diong C, et al. Low-Value Diagnostic Imaging Use in the Pediatric Emergency Department in the United States and Canada. *JAMA Pediatr*. Jun 2019:e191439. doi:10.1001/jamapediatrics.2019.1439

29. Lipshaw MJ, Zamor RL, Carson R, et al. Evidence-based Standardization of Constipation Management in the Emergency Department: A Quality Improvement Study. *Pediatr Qual Saf*. 2021 Mar-Apr 2021;6(2):e395. doi:10.1097/pq9.0000000000000395

30. Arora R, White EN, Niedbala D, et al. Reducing Computed Tomography Scan Utilization for Pediatric Minor Head Injury in the Emergency Department: A Quality Improvement Initiative. *Acad Emerg Med*. Dec 2020;doi:10.1111/acem.14177

31. Ralston SL, Garber MD, Rice-Conboy E, et al. A Multicenter Collaborative to Reduce Unnecessary Care in Inpatient Bronchiolitis. *Pediatrics*. Jan 2016;137(1)doi:10.1542/peds.2015-0851

32. Winder MM, Marietta J, Kerr LM, et al. Reducing Unnecessary Diagnostic Testing in Pediatric Syncope: A Quality Improvement Initiative. *Pediatr Cardiol*. Feb 2021;doi:10.1007/s00246-021-02567-4

33. Ralston S, Comick A, Nichols E, Parker D, Lanter P. Effectiveness of quality improvement in hospitalization for bronchiolitis: a systematic review. *Pediatrics*. Sep 2014;134(3):571-81. doi:10.1542/peds.2014-1036

34. Alpern ER, Stanley RM, Gorelick MH, et al. Epidemiology of a pediatric emergency medicine research network: the PECARN Core Data Project. *Pediatr Emerg Care*. Oct 2006;22(10):689-99. doi:10.1097/01.pec.0000236830.39194.c0

35. Sands R, Shanmugavadivel D, Stephenson T, Wood D. Medical problems presenting to paediatric emergency departments: 10 years on. *Emerg Med J*. May 2012;29(5):379-82. doi:10.1136/emj.2010.106229

36. Armon K, Stephenson T, Gabriel V, et al. Determining the common medical presenting problems to an accident and emergency department. *Arch Dis Child*. May 2001;84(5):390-2. doi:10.1136/ad.84.5.390
37. Shanmugavadivel D, Sands R, Wood D. Common Presenting Problems for Young People Attending the Emergency Department. *Advances in Emergency Medicine*. 2014;5:1-5.
38. Allie EH, Dingle HE, Johnson WN, et al. ED chest radiography for children with asthma exacerbation is infrequently associated with change of management. *Am J Emerg Med*. May 2018;36(5):769-773. doi:10.1016/j.ajem.2017.10.009
39. Ralston SL, Lieberthal AS, Meissner HC, et al. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics*. Nov 2014;134(5):e1474-502. doi:10.1542/peds.2014-2742
40. Niles LM, Goyal MK, Badolato GM, Chamberlain JM, Cohen JS. US Emergency Department Trends in Imaging for Pediatric Nontraumatic Abdominal Pain. *Pediatrics*. Oct 2017;140(4)doi:10.1542/peds.2017-0615
41. Ferguson CC, Gray MP, Diaz M, Boyd KP. Reducing Unnecessary Imaging for Patients With Constipation in the Pediatric Emergency Department. *Pediatrics*. Jul 2017;140(1)doi:10.1542/peds.2016-2290
42. Reuchlin-Vroklage LM, Bierma-Zeinstra S, Benninga MA, Berger MY. Diagnostic value of abdominal radiography in constipated children: a systematic review. *Arch Pediatr Adolesc Med*. Jul 2005;159(7):671-8. doi:10.1001/archpedi.159.7.671
43. Tabbers MM, DiLorenzo C, Berger MY, et al. Evaluation and treatment of functional constipation in infants and children: evidence-based recommendations from ESPGHAN and NASPGHAN. *J Pediatr Gastroenterol Nutr*. Feb 2014;58(2):258-74. doi:10.1097/MPG.0000000000000266
44. Feudtner C, Feinstein JA, Zhong W, Hall M, Dai D. Pediatric complex chronic conditions classification system version 2: updated for ICD-10 and complex medical technology

dependence and transplantation. *BMC Pediatr.* Aug 2014;14:199. doi:10.1186/1471-2431-14-199

45. Warren DW, Jarvis A, LeBlanc L, et al. Revisions to the Canadian Triage and Acuity Scale paediatric guidelines (PaedCTAS). *CJEM.* May 2008;10(3):224-43.

46. van Veen M, Moll HA. Reliability and validity of triage systems in paediatric emergency care. *Scand J Trauma Resusc Emerg Med.* Aug 2009;17:38. doi:10.1186/1757-7241-17-38

47. Magalhães-Barbosa MC, Robaina JR, Prata-Barbosa A, Lopes CS. Reliability of triage systems for paediatric emergency care: a systematic review. *Emerg Med J.* Apr 2019;36(4):231-238. doi:10.1136/emermed-2018-207781

48. de Magalhães-Barbosa MC, Robaina JR, Prata-Barbosa A, Lopes CS. Validity of triage systems for paediatric emergency care: a systematic review. *Emerg Med J.* Nov 2017;34(11):711-719. doi:10.1136/emermed-2016-206058

49. Scott SD, Albrecht L, Given LM, et al. Pediatric information seeking behaviour, information needs, and information preferences of health care professionals in general emergency departments: Results from the Translating Emergency Knowledge for Kids (TREKK) Needs Assessment. *CJEM.* 01 2018;20(1):89-99. doi:10.1017/cem.2016.406

50. Hanley G. Summary of the evidence volume-outcome relationship in pediatric surgery: full report. In: BC CH, editor. Vancouver BC: Child Health BC; 2013.

51. Luft HS, Hunt SS, Maerki SC. The volume-outcome relationship: practice-makes-perfect or selective-referral patterns? *Health Serv Res.* Jun 1987;22(2):157-82.

52. McAteer JP, LaRiviere CA, Drugas GT, Abdullah F, Oldham KT, Goldin AB. Influence of surgeon experience, hospital volume, and specialty designation on outcomes in pediatric surgery: a systematic review. *JAMA Pediatr.* May 2013;167(5):468-75. doi:10.1001/jamapediatrics.2013.25

53. Halm EA, Lee C, Chassin MR. Is volume related to outcome in health care? A systematic review and methodologic critique of the literature. *Ann Intern Med*. Sep 2002;137(6):511-20. doi:10.7326/0003-4819-137-6-200209170-00012
54. Doan Q, Wong H, Meckler G, et al. The impact of pediatric emergency department crowding on patient and health care system outcomes: a multicentre cohort study. *CMAJ*. 06 2019;191(23):E627-E635. doi:10.1503/cmaj.181426
55. Sills MR, Fairclough D, Ranade D, Kahn MG. Emergency department crowding is associated with decreased quality of care for children with acute asthma. *Ann Emerg Med*. Mar 2011;57(3):191-200.e1-7. doi:10.1016/j.annemergmed.2010.08.027
56. Moylan A, Maconochie I. Demand, overcrowding and the pediatric emergency department. *CMAJ*. 06 2019;191(23):E625-E626. doi:10.1503/cmaj.190610
57. Chan M, Meckler G, Doan Q. Paediatric emergency department overcrowding and adverse patient outcomes. *Paediatr Child Health*. Oct 2017;22(7):377-381. doi:10.1093/pch/pxx111
58. Guttman A, Cairney J, MacCon K, Kumar M. Uptake of Ontario's enhanced 18-month well-baby visit: an AHRQ report. Toronto, ON: Institute for Clinical Evaluative Sciences; 2016.
59. Canadian Institute for Health Information (CIHI). NACRS Emergency Department Visits and Length of Stay by province/territory, 2018-2019. Ottawa, ON: Canadian Institute for Health Information; 2019.
60. Health Quality Ontario (HQO). Under pressure: emergency department performance in Ontario. In: Ontario HQ, editor.: Health Quality Ontario; 2016.

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Figure captions

Figure 1. Unscheduled pediatric emergency department discharges at Ontario hospitals between 2010 and 2019

Figure 2. Pediatric radiograph use by hospital-type at Ontario emergency departments between 2010-2019¹

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

Figure 3. Pediatric radiograph use by pediatric volumes at Ontario emergency departments between 2010-2019¹

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

Figure 4. Pediatric radiograph use by physician specialty at Ontario emergency departments between 2010-2019¹

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

²Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

Table captions

Table 1. Characteristics of unscheduled pediatric emergency department discharges in Ontario hospitals between 2010-2019

¹ Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

² Missing data was limited to the following variables: neighborhood income quintile [n = 2,413 (0.4%)], rurality [n = 831 (0.1%)], CTAS score [n = 1,054 (0.3%)], physician specialty [n = 15,078 (2.3%)], physician sex [n = 15,078 (2.3%)], and physician years in practice [n = 15,092 (2.3%)], and physician domestic vs international training [n = 77,154 (11.9%)].

Table 2. Outcomes following pediatric emergency department discharges for Ontario hospitals between 2010-2019¹

¹ Results for death within seven days were not reported due to small cell numbers (n=1-5) in order to ensure data confidentiality.

Supplemental Table 1. Pediatric radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding patients with chronic complex conditions¹

¹ All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

² Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

Supplemental Table 2. Pediatric radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding return visits within 72h¹

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¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

² Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

Supplemental Table 3. Pediatric radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding low pediatric volume hospitals¹

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

² Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

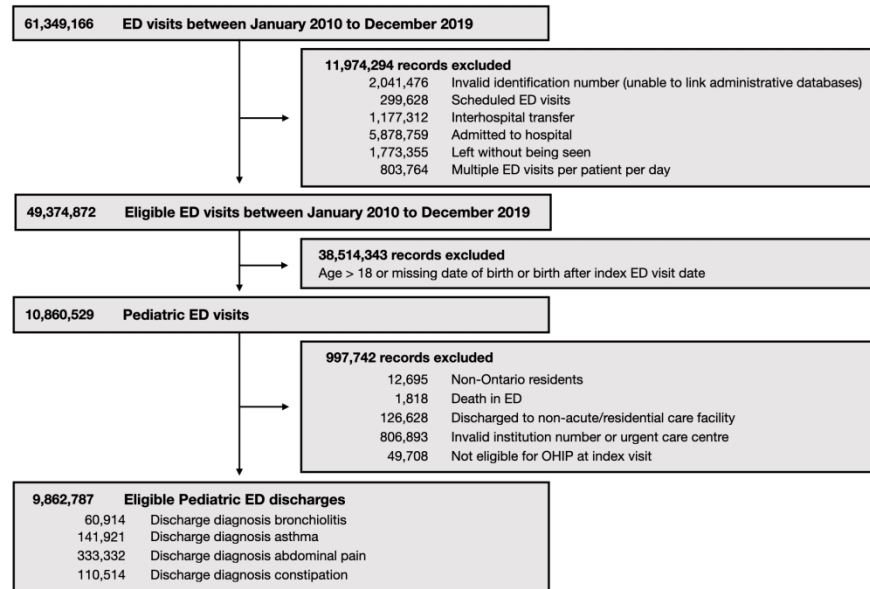


Figure 1. Unscheduled pediatric emergency department discharges at Ontario hospitals between 2010 and 2019

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Table 1. Characteristics of unscheduled pediatric emergency department discharges in Ontario hospitals between 2010-2019

		Bronchiolitis N = 60,914	Asthma N = 141,921	Abdominal pain N = 333,332	Constipation N = 110,514
Clinical characteristics					
Age (years), mean ± SD		0.7 ± 1.6	7.4 ± 5.2	11.1 ± 5.1	6.4 ± 5.2
Sex, n (%)	Female	23,305 (38.3%)	53,999 (38.0%)	199,573 (59.9%)	58,142 (52.6%)
Neighbourhood income quintile ² , n (%)	1 (low)	15,170 (24.9%)	34,622 (24.4%)	69,313 (20.8%)	26,020 (23.5%)
	2	11,801 (19.4%)	28,750 (20.3%)	63,696 (19.1%)	21,958 (19.9%)
	3	12,235 (20.1%)	28,054 (19.8%)	66,582 (20.0%)	22,265 (20.1%)
	4	12,428 (20.4%)	26,840 (18.9%)	69,760 (20.9%)	22,176 (20.1%)
	5 (high)	8,993 (14.8%)	23,043 (16.2%)	62,896 (18.9%)	17,666 (16.0%)
Rurality ² , n (%)	Rural	8,813 (14.5%)	25,746 (18.1%)	48,779 (14.6%)	18,235 (16.5%)
Immigrant or refugee status, n (%)		226 (0.4%)	2,938 (2.1%)	18,887 (5.7%)	3,450 (3.1%)
Chronic Complex Condition, n (%)		1,544 (2.5%)	1,978 (1.4%)	6,837 (2.1%)	2,524 (2.3%)
Canadian Triage Acuity Score (CTAS) ² , n (%)	1	711 (1.2%)	2,119 (1.5%)	192 (0.1%)	71 (0.1%)
	2	21,678 (35.6%)	44,856 (31.6%)	42,427 (12.7%)	10,035 (9.1%)
	3	30,865 (50.7%)	66,914 (47.1%)	224,568 (67.4%)	62,584 (56.6%)
	4	7,096 (11.6%)	25,407 (17.9%)	60,726 (18.2%)	33,745 (30.5%)
	5	480 (0.8%)	2,358 (1.7%)	4,921 (1.5%)	3,884 (3.5%)

Time of ED presentation, n (%)	Mon-Fri: 08:01 to 16:00	17,995 (29.5%)	36,232 (25.5%)	102,679 (30.8%)	33,634 (30.4%)
	Mon-Fri: 16:01 to 24:00 OR Sat/Sun: 08:01 to 16:00	25,479 (41.8%)	56,697 (39.9%)	135,920 (40.8%)	46,643 (42.2%)
	Mon-Fri: 00:01 to 08:00 OR Sat/Sun: 16:01 to 08:00	15,052 (24.7%)	44,476 (31.3%)	87,294 (26.2%)	27,166 (24.6%)
	Holidays	2,388 (3.9%)	4,516 (3.2%)	7,439 (2.2%)	3,071 (2.%)
ED length of visit, n (%)	< 2 hours	18,030 (29.6%)	49,204 (34.7%)	82,021 (24.6%)	37,380 (33.8%)
	2-4 hours	26,800 (44.0%)	57,395 (40.4%)	132,409 (24.6%)	47,664 (43.1%)
	4-6 hours	11,125 (18.3%)	23,786 (16.8%)	74,247 (22.3%)	17,909 (16.2%)
	≥ 6 hours	4,890 (8.0%)	11,247 (7.9%)	43,785 (13.1%)	7,278 (6.6%)
Physician characteristics					
Physician specialty ² , n (%)	PEM	9,895 (16.2%)	16,837 (11.9%)	25,017 (7.5%)	13,487 (12.2%)
	EM	3,267 (5.4%)	7,568 (5.3%)	25,995 (7.8%)	6,376 (5.8%)
	FP + EM	21,224 (34.8%)	52,564 (37.0%)	149,865 (45.0%)	36,239 (32.8%)
	Pediatrics	8,810 (14.5%)	13,075 (9.2%)	21,077 (6.3%)	14,251 (12.9%)
	GP/FP	14,809 (24.3%)	45,503 (32.1%)	97,388 (29.2%)	34,289 (31.0%)
	Other ¹	1,280 (2.1%)	2,197 (1.5%)	7,554 (2.3%)	3,036 (2.7%)
Sex ² , n (%)	Female	19,635 (32.2%)	38,876 (27.4%)	90,286 (27.1%)	34,580 (31.3%)
Age, Mean ± SD		44.3 ± 9.0	44.7 ± 9.5	43.9 ± 9.2	44.5 ± 9.4
Years in practice ² , Mean ± SD		15.9 ± 10.2	16.7 ± 10.7	15.7 ± 10.3	16.1 ± 10.5

International Medical Graduate ² , n (%)		8,914 (14.6%)	17,914 (12.6%)	41,335 (29.8%)	35,166 (31.8%)
Hospital Characteristics					
Hospital type, n (%)	Pediatric academic hospitals	19,612 (32.2%)	31,430 (22.1%)	54,017 (16.2%)	32,592 (29.5%)
	Academic hospitals	1,927 (3.2%)	5,368 (3.8%)	20,147 (6.0%)	4,454 (4.0%)
	Community/small hospitals with pediatric consultation	27,806 (45.6%)	65,212 (45.9%)	183,374 (55.0%)	46,131 (41.7%)
	All other community/small hospitals	11,569 (19.0%)	39,911 (28.1%)	75,794 (22.7%)	27,337 (24.7%)
ED volume, n (%)	Low	2,056 (3.4%)	9,777 (6.9%)	20,357 (6.1%)	6,070 (5.5%)
	Medium	8,391 (13.8%)	26,355 (18.6%)	55,458 (16.6%)	19,061 (17.2%)
	High	50,467 (82.8%)	105,789 (74.5%)	257,517 (77.3%)	85,383 (77.3%)

¹ Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

² Missing data was limited to the following variables: neighborhood income quintile [n = 2,413 (0.4%)], rurality [n = 831 (0.1%)], CTAS score [n = 1,054 (0.3%)], physician specialty [n = 15,078 (2.3%)], physician sex [n = 15,078 (2.3%)], and physician years in practice [n = 15,092 (2.3%)], and physician domestic vs international training [n = 77,154 (11.9%)].

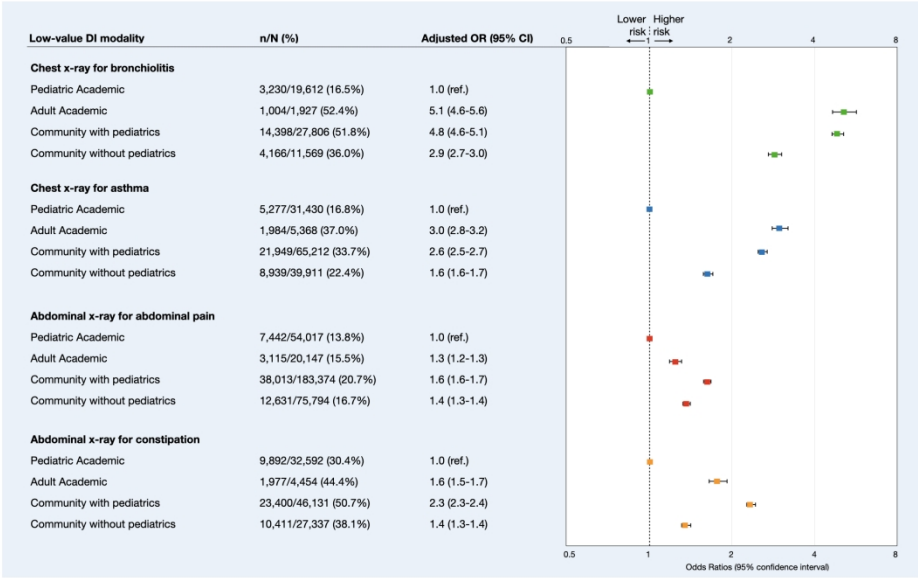


Figure 2. Pediatric radiograph use by hospital-type at Ontario emergency departments between 2010-2019

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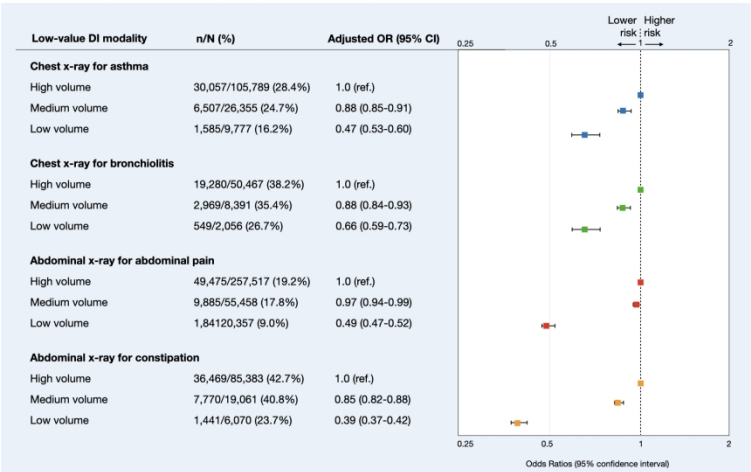


Figure 3. Pediatric radiograph use by pediatric volumes at Ontario emergency departments between 2010-2019

846x564mm (72 x 72 DPI)

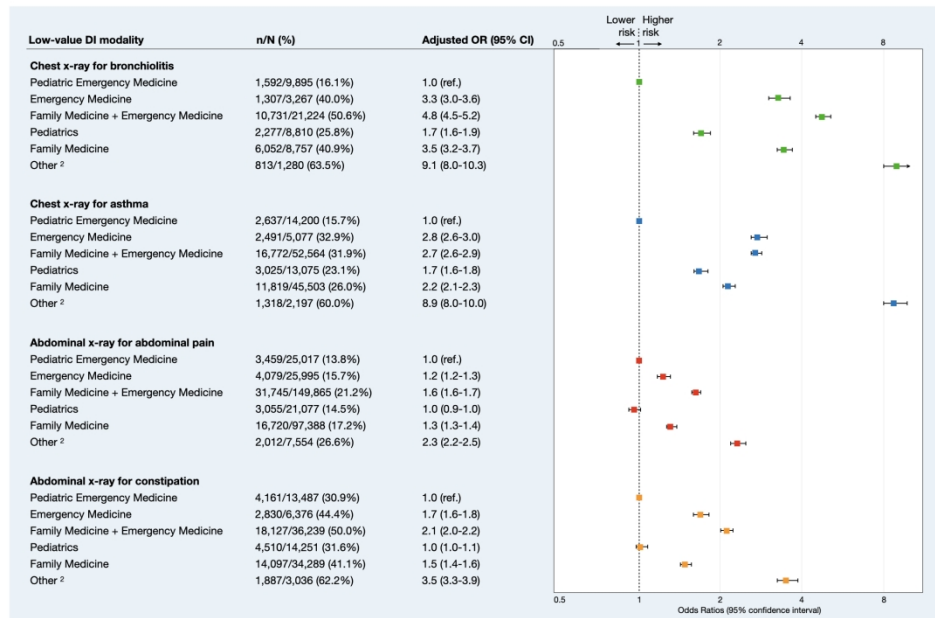


Figure 4. Pediatric radiograph use by physician specialty at Ontario emergency departments between 2010-2019

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Table 2. Outcomes following pediatric emergency department discharges for Ontario hospitals between 2010-2019¹

	Bronchiolitis			Asthma			Abdominal pain			Constipation		
	Imaging N= 22,798	No imaging N= 38,116	Risk difference (95% CI)	Imaging N= 38,149	No imaging N= 103,772	Risk difference (95% CI)	Imaging N= 61,201	No imaging N= 272,131	Risk difference (95% CI)	Imaging N= 45,680	No imaging N= 64,834	Risk difference (95% CI)
Return ED visits within 7 days, n (%)	2,958 (13.0)	5,744 (15.1)	-0.02 (-0.03 – -0.02)	2,739 (7.2)	7,556 (7.3)	-0.001 (-0.004 – 0.002)	10,896 (17.8)	45,689 (16.8)	0.01 (0.007 – 0.01)	4,757 (10.4)	5,492 (8.5)	0.02 (0.02 – 0.02)
Hospital admission within 7 days, n (%)	1,098 (4.8)	1,928 (5.1)	-0.003 (-0.006 – 0.001)	626 (1.6)	1,108 (1.1)	0.006 (0.004 – 0.007)	1,418 (2.3)	5,258 (1.9)	0.004 (0.003 – 0.005)	728 (1.6)	635 (1.0)	0.006 (0.005 – 0.008)
ICU admission within 7 days, n (%)	57 (0.3)	100 (0.3)	-0.0001 (-0.001 – 0.0007)	33 (0.1)	86 (0.1)	0.00004 (-0.0003 – 0.0003)	31 (0.1)	95 (0.0)	0.0002 (-0.00003 – 0.00035)	31 (0.1)	26 (0.0)	0.0003 (-0.00001 – 0.0006)

¹Results for death within seven days were not reported due to small cell numbers (n=1-5) in order to ensure data confidentiality

Supplemental Table 1. Pediatric low-value radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding patients with chronic complex conditions¹

	Bronchiolitis OR (95% CI)	Asthma OR (95% CI)	Abdominal pain OR (95% CI)	Constipation OR (95% CI)
Number of observations	N = 57,467	N = 135,044	N = 318,841	N = 104,695
Hospital-type				
Pediatric academic (referent)	1	1	1	1
Adult academic	5.2 (4.7-5.7)	3.0 (2.8-3.2)	1.3 (1.2-1.3)	1.6 (1.5-1.7)
Community hospital with pediatrics	4.9 (4.7-5.2)	2.6 (2.5-3.7)	1.6 (1.6-1.7)	2.4 (2.3-2.4)
Community hospital without pediatrics	2.9 (2.8-3.1)	1.7 (1.6-1.7)	1.4 (1.3-1.4)	1.4 (1.3-1.4)
Pediatric volumes				
High (referent)	1	1	1	1
Medium	0.9 (0.8-0.9)	0.9 (0.9-0.9)	1.0 (0.9-1.0)	0.9 (0.8-0.9)
Low	0.7 (0.6-0.7)	0.6 (0.5-0.6)	0.5 (0.5-0.5)	0.4 (0.4-0.4)
Physician specialty				
Pediatric emergency medicine (referent)	1	1	1	1
Emergency medicine	3.3 (3.0-3.7)	2.8 (2.6-3.0)	1.2 (1.2-1.3)	1.7 (1.6-1.8)
Family medicine + emergency medicine	4.9 (4.6-5.2)	2.8 (2.6-2.9)	1.6 (1.6-1.7)	2.1 (2.0-2.2)
Pediatrics	1.7 (1.6-1.9)	1.7 (1.6-1.8)	1.0 (0.9-1.0)	1.0 (1.0-1.1)
Family medicine / general practice	3.5 (3.3-3.7)	2.2 (2.1-2.3)	1.3 (1.3-1.4)	1.5 (1.4-1.6)
Others ²	9.2 (8.1-10.5)	9.0 (8.1-10.0)	2.3 (2.2-2.5)	3.5 (3.3-3.9)

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

²Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

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Supplemental Table 2. Pediatric low-value radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding return visits within 72h¹

	Bronchiolitis OR (95% CI)	Asthma OR (95% CI)	Abdominal pain OR (95% CI)	Constipation OR (95% CI)
Number of observations	N = 57,467	N = 131,479	N = 295,966	N = 99,980
Hospital-type				
Pediatric academic (referent)	1	1	1	1
Adult academic	5.2 (4.7-5.8)	3.1 (2.9-3.3)	1.3 (1.2-1.4)	1.6 (1.5-1.8)
Community hospital with pediatrics	5.1 (4.8-5.3)	2.7 (2.6-2.8)	1.8 (1.7-1.8)	2.5 (2.4-2.5)
Community hospital without pediatrics	2.9 (2.8-3.1)	1.7 (1.6-1.7)	1.4 (1.4-1.5)	1.4 (1.3-1.4)
Pediatric volumes				
High (referent)	1	1	1	1
Medium	0.86 (0.81-0.91)	0.88 (0.85-0.91)	0.96 (0.94-0.99)	0.84 (0.81-0.87)
Low	0.65 (0.58-0.73)	0.56 (0.52-0.59)	0.48 (0.46-0.51)	0.38 (0.35-0.41)
Physician specialty				
Pediatric emergency medicine (referent)	1	1	1	1
Emergency medicine	3.4 (3.1-3.7)	2.9 (2.7-3.1)	1.3 (1.2-1.4)	1.8 (1.7-1.9)
Family medicine + emergency medicine	5.0 (4.6-5.3)	2.8 (2.7-3.0)	1.8 (1.7-1.8)	2.2 (2.1-2.3)
Pediatrics	1.8 (1.6-1.9)	1.7 (1.6-1.9)	1.0 (0.9-1.0)	1.1 (1.0-1.1)
Family medicine / general practice	3.6 (3.3-3.8)	2.2 (2.1-2.4)	1.4 (1.4-1.5)	1.5 (1.5-1.6)
Others ²	9.0 (7.9-10.3)	9.3 (8.4-10.2)	2.7 (2.5-2.8)	3.8 (3.5-4.2)

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

²Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.

Supplemental Table 3. Pediatric low-value radiograph use by hospital-type, pediatric volume, and physician specialty at Ontario emergency departments between 2010-2019, excluding low pediatric volume hospitals¹

	Bronchiolitis OR (95% CI)	Asthma OR (95% CI)	Abdominal pain OR (95% CI)	Constipation OR (95% CI)
Number of observations	N = 57,098	N = 128,199	N = 306,873	N = 101,791
Hospital-type				
Pediatric academic (referent)	1	1	1	1
Adult academic	5.4 (4.8-5.9)	3.0 (2.8-3.2)	1.5 (1.4-1.6)	1.9 (1.7-2.0)
Community hospital with pediatrics	4.8 (4.6-5.1)	2.6 (2.5-2.7)	1.6 (1.6-1.7)	2.3 (2.3-2.4)
Community hospital without pediatrics	3.0 (2.9-3.2)	1.8 (1.7-1.9)	1.5 (1.4-1.5)	1.6 (1.5-1.6)
Pediatric volumes				
High (referent)	1	1	1	1
Medium	0.88 (0.84-0.93)	0.88 (0.85-0.91)	0.96 (0.94-0.99)	0.85 (0.82-0.88)
Physician specialty				
Pediatric emergency medicine (referent)	1	1	1	1
Emergency medicine	3.3 (3.0-3.7)	2.8 (2.6-3.0)	1.3 (1.3-1.4)	1.8 (1.7-2.0)
Family medicine + emergency medicine	5.0 (4.6-5.2)	2.7 (2.6-2.9)	1.6 (1.6-1.7)	2.2 (2.1-2.3)
Pediatrics	1.7 (1.6-1.9)	1.7 (1.6-1.8)	1.0 (0.9-1.0)	1.0 (1.0-1.1)
Family medicine / general practice	3.6 (3.4-3.9)	2.3 (2.2-2.5)	1.4 (1.3-1.5)	1.6 (1.6-1.7)
Others ²	9.1 (8.0-10.3)	9.0 (8.1-10.0)	2.4 (2.2-2.5)	3.6 (3.3-4.0)

¹All models adjusted for patient age, sex, income quintile, immigrant/refugee status, complex chronic conditions, Canadian Triage Acuity Score, time of presentation, physician sex, physician years in practice, and physician training background (domestic vs international)

²Other physician specialties included critical care medicine, psychiatry, internal medicine, anesthesiology, orthopedic surgery, cardiology, nuclear medicine, otolaryngology, neonatal medicine, general surgery, and 44 others.